DRAFT HEALTH ADVISORY:

SAFE EATING GUIDELINES FOR FISH FROM LAKE SONOMA (SONOMA COUNTY) AND LAKE MENDOCINO (MENDOCINO COUNTY)

August 2006

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FOREWORD

This health advisory provides safe eating guidelines for consumption of various fish species taken from Lake Sonoma (Sonoma County) and Lake Mendocino (Mendocino County). These guidelines were developed as a result of findings of high mercury levels in certain fish tested from these water bodies and are provided to protect against possible adverse health effects from methylmercury as consumed from mercury-contaminated fish. Additionally, the guidelines provide information to aid consumers in selecting fish that are lower in mercury or other contaminants. This report provides background information and a description of the data and criteria used to develop the guidelines. Once completed, the guidelines contained herein will become the final state advisory.

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EXECUTIVE SUMMARY

The North Coast Regional Water Quality Control Board (NCRWQCB) requested that samples of fish from lakes Sonoma and Mendocino (among other water bodies in the region) be collected and analyzed for trace metals, and in some cases, chlorinated hydrocarbon contaminants including pesticides and PCBs (polychlorinated biphenyls) as part of a statewide water quality-monitoring program. This program, formerly the Toxic Substances Monitoring Program, is now part of the Surface Water Ambient Monitoring Program (SWAMP). The Office of Environmental Health Hazard Assessment (OEHHA), of the California Environmental Protection Agency, developed a sampling plan and assisted in the collection of additional fish samples to augment the historical dataset for these lakes, and evaluated the data to determine whether there may be potential adverse health effects associated with the consumption of sport fish from these lakes. Data indicated that, in some fish species in these lakes, concentrations of mercury have accumulated in fish tissues to levels that pose a concern for public health. As a result, OEHHA developed fish consumption guidelines for Lake Sonoma and Lake Mendocino as described in this report.

Mercury is a trace metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and is also redistributed as a result of human activities such as mining and the burning of fossil fuels. Once mercury is released into the environment, it cycles through land, air, and water. In aquatic systems, it undergoes chemical transformation to the more toxic organic form, methylmercury, which accumulates in fish and other organisms. More than 95 percent of the mercury found in fish occurs as methylmercury, which is a highly toxic form of the element. Almost all fish contain detectable levels of mercury, as methylmercury. Consumption of fish is the major route of exposure to methylmercury in the United States. For more information on mercury, see Appendix I.

The critical target of methylmercury toxicity is the nervous system, particularly in developing organisms such as the fetus and young children. Significant methylmercury toxicity can occur to the fetus during pregnancy even in the absence of symptoms in the mother. In 1985, the United States Environmental Protection Agency (U.S. EPA) set a reference dose (that is the daily exposure likely to be without significant risks of deleterious effects during a lifetime) for methylmercury of $3x10^{-4}$ milligrams per kilogram of body weight per day (mg/kg-day), based on central nervous system effects (ataxia, or loss of muscular coordination; and paresthesia, a sensation of numbness and tingling) in adults. This reference dose (RfD) was lowered to $1x10^{-4}$ mg/kg-day in 1995 (and confirmed in 2001), based on developmental neurologic abnormalities in infants exposed *in utero*. Because OEHHA finds convincing evidence that the fetus is more sensitive than adults to the neurotoxic effects of mercury, but also recognizes that fish can play an important role in a healthy diet, OEHHA chooses to use both the current and previous U.S. EPA reference doses for two distinct population groups. In this advisory, the current RfD based on effects in infants will be used for women of childbearing age and children aged 17 years and younger. The previous RfD, based on effects in adults, will be used for women beyond their childbearing years and men.

Mercury concentrations in the fish were compared to guidance tissue levels for methylmercury, which are designed so that individuals consuming no more than a preset number of meals should not exceed the reference dose for this chemical. Evaluation of data and comparison with guidance tissue levels for methylmercury indicated that fish consumption guidelines were appropriate for Lake Sonoma and Lake Mendocino. Fish consumption guidelines provide information to fish consumers as to which fish species have high mercury levels and whose consumption should be

restricted or avoided altogether, as well as other fish species that are lower in mercury (or other contaminants) that could be consumed more frequently. A statistically representative sample size was available to provide guidelines for largemouth bass, redear sunfish, and black crappie from Lake Sonoma; and for largemouth bass and redear sunfish from Lake Mendocino. Supporting data (such as mercury concentration for a closely related species at a similar trophic level) were used to develop additional consumption guidelines for other sport fish species as appropriate.

All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to follow the consumption guidelines in order to keep fish part of a healthy diet while ensuring that methylmercury ingestion does not exceed the reference dose. To help sport fish consumers achieve this goal, OEHHA has developed the advice contained in this report for fish collected from lakes Sonoma and Mendocino.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), see the California Sport Fish Consumption Advisories (http://www.oehha.ca.gov/fish.html) or Appendix II. Site-specific advice for other California water bodies can be found online at: http://www.oehha.ca.gov/fish/so_cal/index.html. It should be noted that, unlike the case for many fat-soluble organic contaminants, various cooking and cleaning techniques will not reduce the methylmercury content of fish.

SAFE EATING GUIDELINES
FISH CONSUMPTION FROM LAKE SONOMA

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. The American Heart Association recommends healthy adults eat at least two meals of fish a week. OEHHA recommends that you choose fish to eat that are lower in mercury. Because some types of fish from Lake Sonoma contain high levels of mercury, OEHHA provides the recommendations below that you can follow to reduce the risks from exposure to methylmercury in fish.

Women of childbearing age, pregnant or breastfeeding women, and children 17 years and younger

EAT IN MODERATION **No more than 1 meal a week**
Sunfish or crappie
AVOID **No more than 1 meal a month**
Largemouth or smallmouth bass

Women beyond childbearing age and men

BEST CHOICES **Up to 2 meals a week**
Sunfish or crappie
EAT IN MODERATION **No more than 1 meal a week**
Largemouth or smallmouth bass

- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish build up mercury in their bodies as they grow.
- **MEAL SIZE DEPENDS ON BODY WEIGHT.** Meals are based on a 160-pound adult eating 8 ounces of fish (6 ounces after cooking) — about the size of two decks of cards. If you weigh less than 160 pounds, eat smaller portions of fish. Serve smaller meals to children.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. Do not eat more than one of the listed fish species during the same time period unless you are eating from the Best Choices (green) category. If you eat fish from one place, following the advisory, avoid eating fish from other sources during the same time period.
- **CONSIDER THE FISH YOU BUY FROM STORES AND RESTAURANTS.** Women of childbearing age and children can safely eat up to 2 meals a week of most fish purchased in a store or restaurant, **OR** use this guide for eating fish caught from this water body. In a week when you eat 2 meals of fish purchased from stores or restaurants, avoid eating fish caught from a local water body. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury. Women of childbearing age and children should not eat shark or swordfish, which contain the most mercury.
- **FISH FROM OTHER WATER BODIES MAY ALSO CONTAIN MERCURY**. Not all water bodies in California have been tested. With the exception of ocean or river-run salmon or steelhead, which may be consumed more frequently, fish caught from places without an advisory should be eaten in limited amounts.

SAFE EATING GUIDELINES
FISH CONSUMPTION FROM LAKE MENDOCINO

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. The American Heart Association recommends healthy adults eat at least two meals of fish a week. OEHHA recommends that you choose fish to eat that are lower in mercury. Because some types of fish from Lake Mendocino contain high levels of mercury, OEHHA provides the recommendations below that you can follow to reduce the risks from exposure to methylmercury in fish.

Women of childbearing age, pregnant or breastfeeding women, and children 17 years and younger

EAT IN MODERATION **No more than 1 meal a week**
Sunfish or crappie
AVOID **No more than 1 meal a month**
Largemouth or smallmouth bass

Women beyond childbearing age and men

BEST CHOICES **Up to 2 meals a week**
Sunfish or crappie
EAT IN MODERATION **No more than 1 meal a week**
Largemouth or smallmouth bass

- Incomplete information from Lake Mendocino indicates that you should avoid eating striped bass, and channel catfish should be eaten in limited amounts (no more than 1 meal a week).
- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish build up mercury in their bodies as they grow.
- **MEAL SIZE DEPENDS ON BODY WEIGHT.** Meals are based on a 160-pound adult eating 8 ounces of fish (6 ounces after cooking) — about the size of two decks of cards. If you weigh less than 160 pounds, eat smaller portions of fish. Serve smaller meals to children.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. Do not eat more than one of the listed fish species during the same time period unless you are eating from the Best Choices (green) category. If you eat fish from one place, following the advisory, avoid eating fish from other sources during the same time period.
- **CONSIDER THE FISH YOU BUY FROM STORES AND RESTAURANTS.** Women of childbearing age and children can safely eat up to 2 meals a week of most fish purchased in a store or restaurant, **OR** use this guide for eating fish caught from this water body. In a week when you eat 2 meals of fish purchased from stores or restaurants, avoid eating fish caught from a local water body. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury. Women of childbearing age and children should not eat shark or swordfish, which contain the most mercury.
- **FISH FROM OTHER WATER BODIES MAY ALSO CONTAIN MERCURY**. Not all water bodies in California have been tested. With the exception of ocean or river-run salmon or steelhead, which may be consumed more frequently, fish caught from places without an advisory should be eaten in limited amounts.

LAKE SONOMA AND LAKE MENDOCINO SPORT FISH

Note: Images are not to scale

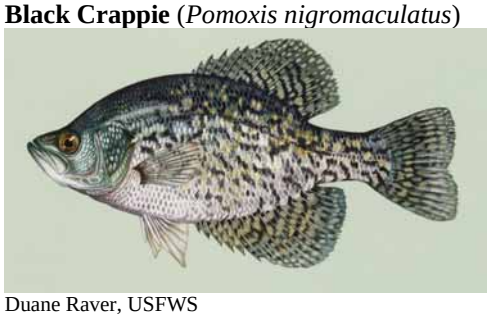
Largemouth Bass (*Micropterus salmoides*)

Duane Raver, USFWS

Smallmouth Bass (*Micropterus dolomieu*)

Duane Raver, USFWS

Black Crappie (*Pomoxis nigromaculatus*)



Duane Raver, USFWS

White Crappie (*Pomoxis annularis*)

Duane Raver, USFWS

Redear Sunfish (*Lepomis microlophus)*

Duane Raver, USFWS

Bluegill (*Lepomis macrochirus*)

Duane Raver, USFWS

Green Sunfish (*Lepomis cyanellus*)

Duane Raver, USFWS

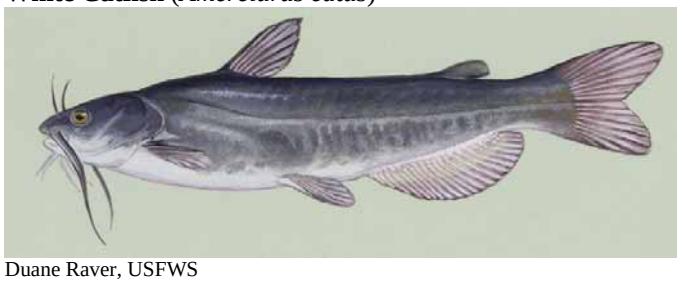
Sacramento perch *(Archoplites interruptus*)

Diane Rome Peebles

Channel Catfish (*Ictalurus punctalus*)

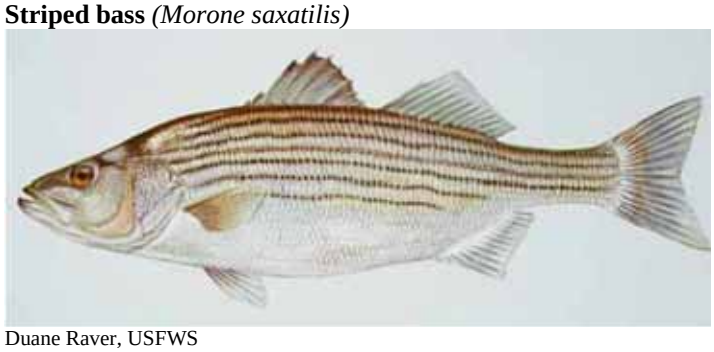
Duane Raver, USFWS

White Catfish (*Amereiurus catus*)



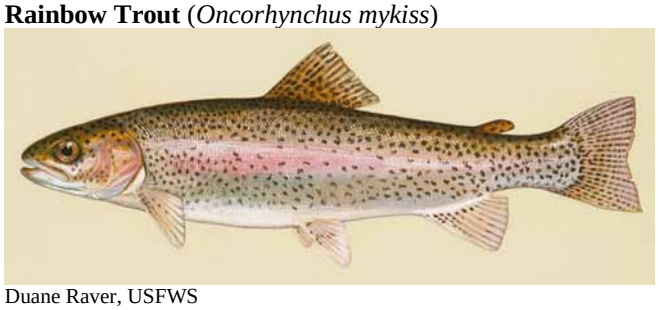
Duane Raver, USFWS

Striped bass *(Morone saxatilis)*



Duane Raver, USFWS

Rainbow Trout (*Oncorhynchus mykiss*)



Duane Raver, USFWS

INTRODUCTION

Elevated levels of mercury have been found in fish in a number of lakes and reservoirs in northern California. The Office of Environmental Health Hazard Assessment (OEHHA), of the California Environmental Protection Agency cooperated with the North Coast Regional Water Quality Control Board (NCRWQCB) to augment historical sampling and analysis of fish from Lake Sonoma and Lake Mendocino (Sonoma and Mendocino counties, respectively) under the Surface Water Ambient Monitoring Program (SWAMP; formerly the Toxic Substance Monitoring Program). OEHHA developed a sampling design, assisted with collection of fish, and evaluated both the historical and recent fish tissue data to develop the advisories contained in this report.

Mercury is a trace metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and exists in various forms including elemental or metallic mercury, inorganic, and organic mercury (ATSDR, 1999; IARC, 1993). Cinnabar ores, naturally rich in mercury, are common in northern California, and mercury was extensively mined in California in the 1800s and early 1900s. Mercury enters the environment from the breakdown of minerals in rocks and leaching from old mine sites. It is also emitted into air from mining deposits, the burning of fossil fuels, and other industrial sources, as well as from volcanic emissions. Mercury contamination thus occurs as a result of both natural and anthropogenic sources and processes. Once mercury is released into the environment, it cycles through land, air, and water. The deposition of mercury in aquatic ecosystems is a concern for public and environmental health because microorganisms (bacteria and fungi) in the sediments can convert inorganic mercury into organic methylmercury, a particularly toxic form of mercury. Once formed, methylmercury accumulates or "biomagnifies" in the aquatic food chain, reaching the highest levels in fish and other organisms at the top of the food web. Concentrations of methylmercury in fish tissues can therefore be orders of magnitude greater than concentrations in water. Consumption of fish is the principal route of exposure to methylmercury. Whether consumption of fish is harmful depends on the concentrations of methylmercury in the fish and the amount of fish consumed.

OEHHA is the agency responsible for evaluating public health impacts from chemical contamination of sport fish, and issuing advisories, when needed, for the state of California. OEHHA's authorities to conduct these activities are based on mandates in the California Health and Safety Code, Section 59009, to protect public health, and Section 59011, to advise local health authorities; and the California Water Code Section 13177.5, to issue health advisories. Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations of the California Department of Fish and Game (CDFG). OEHHA now emphasizes "safe eating guidelines" in these advisories in an effort to inform consumers of healthy choices in fish consumption as well as fish species that should be avoided or restricted.

In evaluating the fish tissue data for Lake Sonoma and Lake Mendocino, it was determined that some fish species in each of these lakes had sufficient levels of mercury that could be a concern for frequent sport fish consumers. Because fish consumption advice was not currently in place for Lake Sonoma or Lake Mendocino, development of consumption guidelines was deemed appropriate for these lakes.

BACKGROUND

Lake Sonoma is located 15 miles north of Santa Rosa in Dry Creek Valley, Sonoma County (Figure 1). The reservoir was formed in 1983 following the construction of Warm Springs Dam, 3000 feet in length and 319 feet high, and provides for flood control, irrigation and recreation

(U.S. Army Corps of Engineers, 2005; Dean's AnglerNet, 2005a). A fish hatchery operated by the California Department of Fish and Game (DFG) was constructed to replace and enhance salmon and steelhead spawning grounds (U.S. Army Corps of Engineers, 2005). The lake has about 2,700 surface acres when full and 50 miles of shoreline with coves, grass flats, and rock piles. When the reservoir was formed, trees were left standing that now provide excellent habitat for largemouth and smallmouth bass; other fish species include Sacramento perch, channel catfish, crappie, redear sunfish, green sunfish, landlocked steelhead, and bluegill (Dean's AnglerNet, 2005a; Dean's AnglerNet, 2005b; Bacher, 1999). There is also a small, reproducing native population of trout that are holdovers from steelhead that migrated up Dry Creek before the lake was formed (Dean's AnglerNet, 2005b; Bacher, 1999). The two primary arms in the lake, Warm Springs Arm and Dry Creek Arm, are both considered excellent for fishing. Lake Sonoma is primarily a boating lake; launching is provided at several boat ramps (Dean's AnglerNet, 2005a.)

Lake Mendocino is situated in the foothills of the northern Coast Range in Coyote Valley, Mendocino County. The 1,822-acre reservoir was created in 1958 by the completion of Coyote Dam on the East Fork of the Russian River. The dam is 3,500 feet long and provides flood control, water conservation, and hydroelectric power (Dean's AnglerNet, 2005c). Striped bass, largemouth and smallmouth bass, crappie, bluegill, and catfish are abundant fish species in the lake. The lake provides numerous recreational activities in addition to fishing and there is also a seasonal fish hatchery. Pomo Indians once resided in the valley; Native Americans and the Army Corps of Engineers now jointly operate the visitor center at the lake.

Both Lake Sonoma and Lake Mendocino are located in the California Coast Range, one of the most productive mercury districts in the world (BLM and USGS, 2005; Middleton, 2003). The discovery of mercury ore in the Coast Range led to the development and operation of numerous mines from the 1840s to the early 1960s. Some of these mines were located in the West Mayacmas mining district in northeast Sonoma County; where many small and several principal mines produced moderate amounts of mercury (U.S. Bureau of Mines, 1965). Significant amounts of mercury enter the environment from the mercury mines located in the coastal range (Kim *et al*., 2005).

Staff from the California Department of Fish and Game collected fish from Lake Sonoma in 1989–1993, 1995–1997, and 1999–2001; and from Lake Mendocino in 1989–1993, 1999, and 2001. Sampling was performed primarily using electrofishing equipment, or nets and hook and line. Species collected included black crappie, redear sunfish, and largemouth bass from Lake Sonoma, and channel catfish, largemouth bass, striped bass, redear sunfish, and rainbow trout at Lake Mendocino. Fish were measured (in fork length) and weighed, and analyzed as individuals or composite samples using skin-off muscle fillet. Prior to 1997, composite samples were homogenized at the CDFG Water Pollution Control Laboratory (WPCL) and analyzed for total mercury by cold vapor atomic absorption spectrophotometry; since 1997, samples have been analyzed for mercury and other trace metals by Moss Landing Marine Laboratory (MLML).

Data can be used for developing fish consumption advisories when certain sampling criteria are met. For example, U.S. EPA recommends a minimum of three replicate composite samples of three fish per composite (nine total fish) in order to begin assessing the magnitude of contamination at a site. U.S. EPA also recommends that at least two fish species be sampled per site. Although composite analysis is generally the most cost-efficient method of estimating the average concentration of chemicals in a fish species, individual sampling provides a better measure of the range and variability of contaminant levels in a fish population (U.S. EPA, 2000a). Using these guidelines, OEHHA believes that a minimum of three replicates of three fish per composite

or, preferably, nine individual fish samples of multiple species from each water body should be analyzed for the purpose of assessing the potential risks from consumption of fish from the water body. Species of fish that do not grow large (*e.g.*, sunfish) usually require more than three individuals per composite to provide sufficient tissue for analysis; this additional number of individuals will also make the samples more representative. When feasible, fish samples should be collected from multiple (legal or edible) sizes when a large size range exists in that species. Following this sampling protocol will allow estimation of the range and variation of contaminant concentrations at a particular site and derivation of a representative mean concentration for use in developing fish consumption advisories. However, more samples will provide a better estimate of the mean contaminant level in various fish species and are especially important for large water bodies.

Only legal and/or edible size fish were included in this evaluation. Minimum size requirements are shown in Table 1, and the case summaries in Appendix III present all data and indicate which of the data were selected and used in this evaluation.

In addition to analyses for mercury, limited analyses for chlorinated hydrocarbon contaminants (including pesticides and polychlorinated biphenyls or PCBs) were conducted for a few samples from Lake Sonoma and Lake Mendocino. These analyses were conducted with homogenized tissue analyzed by gas chromatography using mass spectrometry (GC/MS) for chlorinated hydrocarbon determination. For Lake Sonoma, five samples comprised of 24 largemouth bass collected in 1989, 1995, and 1997 were analyzed for organic contaminants. None of the chemicals were measured at levels of health concern, and most chemicals were not detected. These samples of largemouth bass had relatively low lipid content (less than one percent). In addition, one composite of nine small rainbow trout (less than the minimum size criterion) collected in 1996 from Dry Creek downstream of Lake Sonoma was analyzed for organic chemicals. Although lipid content was higher (3.5 percent) in this sample, none of the chemicals were measured at levels of health concern, and most chemicals were not detected. For Lake Mendocino, one composite of six redear sunfish collected in 1992 was analyzed for organic chemicals. None of the organic chemicals were detected in the redear sunfish. Additionally, a large individual channel catfish (775 mm) was collected in 2001 and analyzed for organics. This fish had a lipid content of 7.3 percent and the concentration of PCBs was 40 ppb. A single fish is inadequate for representing a fish population or for developing consumption advice, but this result indicates that further study of organic contaminants including PCBs is needed for these lakes. With the exception of the single channel catfish sample, the concentrations of PCBs and pesticides (data not shown) were below OEHHA's screening values (Brodberg and Pollock, 1999) used to determine whether further evaluation or site-specific advice should be considered. Given the limited amount of data available for evaluating potential risks from exposure to pesticides or PCBs in fish from Lake Mendocino and Lake Sonoma, it was not possible to determine whether specific consumption guidelines are needed to protect consumers from exposure to these chemicals. The consumption guidelines presented in this report for these two reservoirs are based on mercury concentrations only. For additional advice on preparing and cooking fish to reduce the amount of pesticides and PCBs, see Appendix II.

METHYLMERCURY TOXICOLOGY

Mercury is a metal found naturally in rocks, soil, air, and water that can be concentrated to high levels in the aquatic food chain by a combination of natural processes and human activities (ATSDR), 1999). The toxicity of mercury to humans is greatly dependent on its chemical form (elemental, inorganic, or organic) and route of exposure (oral, dermal, or inhalation).

Methylmercury, an organic form, is highly toxic and can pose a variety of human health risks (NRC/NAS, 2000). Of the total amount of mercury found in fish muscle tissue, methylmercury comprises more than 95 percent (ATSDR, 1999; Bloom, 1992). Because analysis of total mercury is less expensive than that for methylmercury, total mercury is usually analyzed for most fish studies. In this study, total mercury was measured and assumed to be 100 percent methylmercury for the purposes of risk assessment.

Fish consumption is the major route of exposure to methylmercury in the United States (ATSDR, 1999). Almost all fish contain detectable levels of methylmercury, which, when ingested, is almost completely absorbed from the gastrointestinal tract (Aberg *et al.*, 1969; Myers *et al.*, 2000). Once absorbed, methylmercury is distributed throughout the body, reaching the largest concentration in kidneys. Its ability to cross the placenta as well as the blood brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (ATSDR, 1999). In the body, methylmercury is slowly converted to inorganic mercury and excreted predominantly by the fecal (biliary) pathway. Methylmercury is also excreted in breast milk (ATSDR, 1999). The biological half-life of methylmercury is approximately 44 to 74 days in humans (Aberg, 1969; Smith *et al.*, 1994), meaning that it takes approximately 44 to 74 days for one half of a single ingested dose of methylmercury to be eliminated from the body.

Human toxicity of methylmercury has been well studied following several epidemics of human poisoning resulting from consumption of highly contaminated fish (Japan) or seed grain (Iraq, Guatemala, and Pakistan) (Elhassani, 1982-83). The first recorded mass methylmercury poisoning occurred in the 1950s and 1960s in Minamata, Japan, following the consumption of fish contaminated by industrial pollution (Marsh, 1987). The resulting illness was manifested largely by neurological signs and symptoms such as loss of sensation in the hands and feet, loss of gait coordination, slurred speech, sensory deficits including blindness, and mental disturbances (Bakir *et al.*, 1973; Marsh, 1987). This syndrome was subsequently named Minamata Disease. A second outbreak of methylmercury poisoning occurred in Niigata, Japan, in the mid-1960s. In that case, contaminated fish were also the source of illness (Marsh, 1987). In all, more than 2,000 cases of methylmercury poisoning were reported in Japan, including more than 900 deaths (Mishima, 1992).

The largest outbreak of methylmercury poisoning occurred in Iraq in 1971-1972 and resulted from consumption of bread made from seed grain treated with a methylmercury fungicide (Bakir *et al.*, 1973). This epidemic occurred over a relatively short term (several months) compared to the Japanese outbreak. The mean methylmercury concentration of wheat flour samples was found to be 9.1 micrograms per gram (μg/g). Over 6,500 people were hospitalized, with 459 fatalities. Signs and symptoms of methylmercury toxicity were similar to those reported in the Japanese epidemic.

Review of data collected during and subsequent to the Japan and Iraq outbreaks identified the critical target of methylmercury as the nervous system and the most sensitive subpopulation as the developing organism (U.S. EPA, 1997). During critical periods of prenatal and postnatal structural and functional development, the fetus and children are especially susceptible to the toxic effects of methylmercury (ATSDR, 1999; IRIS, 1995). When maternal methylmercury consumption is very high, as happened in Japan and Iraq, significant methylmercury toxicity can occur to the fetus during pregnancy, with only very mild or even in the absence of symptoms in the mother. In those cases, symptoms in children were often not recognized until development of cerebral palsy and/or

mental retardation many months after birth (Harada, 1978; Marsh *et al.*, 1980; Marsh *et al.*, 1987; Matsumoto *et al.*, 1964; Snyder, 1971).

The International Agency for Research on Cancer (IARC) has listed methylmercury compounds as possible human carcinogens, based on inadequate data in humans and limited evidence in experimental animals (increased incidence of tumors in mice exposed to methylmercury chloride) (IARC, 1993). Based on IARC's evaluation, OEHHA has administratively listed methylmercury compounds on the Proposition 65 list of chemicals known to the State of California to cause cancer. No estimate of the increased cancer risk from lifetime exposure has been developed for methylmercury.

DERIVATION OF REFERENCE DOSES FOR METHYLMERCURY

A reference dose (RfD) is an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (IRIS, 1995). Reference doses are expressed in units of milligrams of the chemical of concern per kilogram of body weight per day (mg/kg-day). The estimate includes a safety factor to account for data uncertainty. The underlying assumption of a reference dose is that, unlike carcinogenic effects, there is a threshold dose below which certain toxic effects will not occur. The reference dose for a particular chemical is derived from review of relevant toxicological and epidemiological studies in animals and/or humans. These studies are used to determine a No-Observed-Adverse-Effect-Level (NOAEL; the highest dose at which no adverse effect is seen), a Lowest-Observed-Adverse-Effect-Level (LOAEL; the lowest dose at which any adverse effect is seen), or a benchmark dose level (BMDL; a statistical lower confidence limit of a dose that produces a certain percent change in the risk of an adverse effect) (IRIS, 1995). Based on these values and the application of uncertainty factors to account for incomplete data and sensitive subgroups of the population, a reference dose is then generated. Exposure to a level above the RfD does not mean that adverse effects will occur, only that the possibility of adverse effects occurring has increased (IRIS, 1993).

The first U.S. EPA RfD for methylmercury was developed in 1985 and set at $3x10^{-4}$ mg/kg-day (U.S. EPA, 1997). This RfD was based, in part, on a World Health Organization report summarizing data obtained from several early epidemiological studies on the Iraqi and Japanese methylmercury poisoning outbreaks (WHO, 1976). WHO found that the earliest symptoms of methylmercury intoxication (paresthesias) were reported at blood and hair concentrations ranging from 200 to 500 micrograms per liter (μg/L) and 50-125 μg/g, respectively, in adults. In cases where ingested mercury dose could be estimated (based, for example, on mercury concentration in contaminated bread and number of loaves consumed daily), an empirical correlation between blood and/or hair mercury concentrations and onset of symptoms was obtained. From these studies, WHO determined that methylmercury exposure equivalent to long-term daily intake of 3-7 μg/kg body weight in adults was associated with an approximately 5 percent prevalence of paresthesias (WHO, 1976). U.S. EPA further cited a study by Clarkson *et al.* (1976) to support the range of blood mercury concentrations at which paresthesias were first observed in sensitive members of the adult population. This study found that a small percentage of Iraqi adults exposed to methylmercury-treated seed grain developed paresthesias at blood levels ranging from 240 to 480 μg/L. The low end of this range was considered to be a LOAEL and was estimated to be equivalent to a dosage of 3 μg/kg-day. U.S. EPA applied a ten-fold uncertainty factor to the LOAEL to reach what was expected to be the NOAEL. Because the LOAEL was observed in

sensitive individuals in the population after chronic exposure, additional uncertainty factors were not considered necessary for exposed adults (U.S. EPA, 1997).

Although this RfD was derived on the basis of effects in adults, even at that time researchers were aware that the fetus might be more sensitive to methylmercury (WHO, 1976). It was not until 1995, however, that U.S. EPA had sufficient data from Marsh *et al.* (1987) and Seafood Safety (1991) to develop an oral RfD based on methylmercury exposures during the prenatal stage of development (IRIS, 1995). Marsh *et al.* (1987) collected and summarized data from 81 mother and child pairs where the child had been exposed to methylmercury *in utero* during the Iraqi epidemic. Maximum mercury concentrations in maternal hair during gestation were correlated with clinical signs in the offspring such as cerebral palsy, altered muscle tone and deep tendon reflexes, and delayed developmental milestones that were observed over a period of several years after the poisoning. Clinical effects incidence tables included in the critique of the risk assessment for methylmercury conducted by U.S. FDA (Seafood Safety, 1991) provided dose-response data for a benchmark dose approach to the RfD, rather than the previously used NOAEL/LOAEL method. The BMDL was based on a maternal hair mercury concentration of 11 parts per million (ppm). From that, an average blood mercury concentration of 44 μg/L was estimated based on a hair: blood concentration ratio of 250:1. Blood mercury concentration was, in turn, used to calculate a daily oral dose of 1.1 μg/kg-day, using an equation that assumed steady-state conditions and first-order kinetics for mercury. An uncertainty factor of 10 was applied to this dose to account for variability in the biological half-life of methylmercury, the lack of a two-generation reproductive study and insufficient data on the effects of exposure duration on developmental neurotoxicity and adult paresthesias. The oral RfD was then calculated to be $1x10^{-4}$ mg/kg-day, to protect against developmental neurological abnormalities in infants (IRIS, 1995). This fetal RfD was deemed protective of infants and sensitive adults.

The two previous RfDs for methylmercury were developed using data from high-dose poisoning events. Recently, the National Academy of Sciences was directed to provide scientific guidance to U.S. EPA on the development of a new RfD for methylmercury (NRC/NAS, 2000). Three large prospective epidemiological studies were evaluated in an attempt to provide more precise dose-response estimates for methylmercury at chronic low-dose exposures, such as might be expected to occur in the United States. The three studies were conducted in the Seychelles Islands (Davidson *et al.*, 1995, 1998), the Faroe Islands (Grandjean *et al.*, 1997, 1998, 1999), and New Zealand (Kjellstrom *et al.*, 1986, 1989). The residents of these areas were selected for study because their diets rely heavily on consumption of fish and marine mammals, which provide a continual source of methylmercury exposure (NRC/NAS, 2000).

Although estimated prenatal methylmercury exposures were similar among the three studies, subtle neurobehavioral effects in children were found to be associated with maternal methylmercury dose in the Faroe Islands and New Zealand studies, but not in the Seychelle Islands study. The reasons for this discrepancy were unclear; however, it may have resulted from differences in sources of exposure (marine mammals and/or fish), differences in exposure pattern, differences in neurobehavioral tests administered and age at testing, the effects of confounding variables, or issues of statistical analysis (NRC/NAS, 2000). The National Academy of Sciences report supported the current U.S. EPA RfD of $1x10^{-4}$ mg/kg-day for fetuses, but suggested that it should be based on the Faroe Islands study rather than Iraqi data.

U.S. EPA has recently published a new RfD document that arrives at the same numerical RfD as the previous fetal RfD, using data from all three recent epidemiological studies while placing emphasis on the Faroe Island data (IRIS, 2001). In order to develop an RfD, U.S. EPA used

several scores from the Faroes data, rather than a single measure for the critical endpoint, as is customary (IRIS, 2001). U.S. EPA developed BMDLs utilizing test scores for several different neuropsychological effects with cord blood as the preferred biomarker. The BMDLs for different neuropsychological effects in the Faroes study ranged from 46 to 79 μg mercury/liter blood. U.S. EPA then chose a one-compartment model for conversion of cord blood to ingested maternal dose, which resulted in estimated maternal mercury exposures of 0.857-1.472 μg/kg-day (IRIS, 2001). An uncertainty factor of ten was applied to the oral doses corresponding to the range of BMDLs to account for inter-individual toxicokinetic variability in ingested dose estimation from cord-blood mercury levels and pharmacodynamic variability and uncertainty, leading to an RfD of $1x10^{-4}$ mg/kg-day (IRIS, 2001). In support of this RfD, U.S. EPA found that benchmark dose analysis of several neuropsychological endpoints from the Faroe Island and New Zealand studies, as well as an integrative analysis of all three epidemiological studies, converged on an RfD of $1x10^{-4}$ mg/kg-day (IRIS, 2001). U.S. EPA (IRIS, 2001) now considers this RfD to be protective for all populations. However, in their joint federal advisory for mercury in fish, U.S. EPA and FDA only apply this RfD to women who are pregnant or might become pregnant, nursing mothers, and young children (U.S. EPA, 2004).

OEHHA finds that there is convincing evidence that the fetus is more sensitive than adults to the neurotoxic and subtle neuropsychological effects of methylmercury. As noted previously, during the Japanese and Iraqi methylmercury poisoning outbreaks, significant neurological toxicity occurred to the fetus even in the absence of symptoms in the mother. In later epidemiological studies at lower exposure levels (*e.g.*, in the Faroe Islands), these differences in maternal and fetal susceptibility to methylmercury toxicity were also observed. Recent evidence has shown that the nervous system continues to develop through adolescence (see, for example, Giedd *et al.*, 1999; Paus *et al.*, 1999; Rice and Barone, 2000). As such, it is likely that exposure to a neurotoxic agent during this time may damage neural structure and function (Adams *et al.*, 2000), which may not become evident for many years (Rice and Barone, 2000). Thus, OEHHA considers the RfD based on subtle neuropsychological effects following fetal exposure to be the best estimate of a protective daily exposure level for pregnant or nursing females and children aged 17 years and younger.

OEHHA also recognizes that fish can play an important role in a healthy diet, particularly when it replaces other higher-fat sources of protein. Numerous human and animal studies have shown that fish oils have beneficial cardiovascular and neurological effects (see, for example, Harris and Isley, 2001; Iso *et al.*, 2001; Mori and Beilin, 2001; Daviglus *et al.*, 1997; von Schacky *et al.*, 1999; Valagussa *et al.*, 1999; Moriguchi *et al.*, 2000; Lim and Suzuki, 2000; Cheruka *et al.*, 2002). Nonetheless, the hazards of methylmercury that may be present in fish, particularly to developing fetuses and children, cannot be overlooked. When contaminants are present in a specific food that can be differentially avoided, it is not necessary to treat all populations in the most conservative manner to protect the most sensitive population. Sport fish consumption advisories are such a case. Exposure advice can be tailored to specific risks and benefits for populations with different susceptibilities so that each population is protected without undue burden to the other. Fish consumption guidelines utilize the best scientific data available to provide the most relevant advice and protection for all potential consumers.

In an effort to address the risks of methylmercury contamination in different populations as well as the cardiovascular and neurological benefits of fish consumption, two separate RfDs will be used to assess risk for different population groups. OEHHA has formerly used separate methylmercury RfDs for adults and pregnant females to formulate advisories for methylmercury contamination of sport fish (Stratton *et al.*, 1987). Additionally, most states issue separate consumption advice for

sensitive (*e.g.*, children) and general population groups. OEHHA chooses to use both the current and previous U.S. EPA references doses for two distinct population groups. For these safe-eating guidelines, the current RfD of $1x10^{-4}$ mg/kg-day, based on effects in infants, will be used for women of childbearing age and children aged 17 years and younger. The previous RfD of $3x10^{-4}$ mg/kg-day, based on effects in adults, will be used for women beyond their childbearing years and men.

MERCURY LEVELS IN FISH FROM LAKE SONOMA AND LAKE MENDOCINO

Mercury concentrations in fish and other biota are dependent, in general, on the mercury level of the environment in which they reside. However, there are many factors that affect the accumulation of mercury in fish tissue. Fish species and age (as inferred from length) are known to be important determinants of tissue mercury concentration (WHO, 1989; 1990). Fish at the highest trophic levels (*i.e.*, predatory fish) generally have the highest levels of mercury. Additionally, because the biological half-life of methylmercury in fish is much longer (approximately 2 years) than in mammals, tissue concentrations increase with increased duration of exposure (Krehl, 1972; Stopford and Goldwater, 1975; Tollefson and Cordle, 1986). Thus, tissue methylmercury concentrations are expected to increase with increasing age (length) within a given species. In addition to differences in species, size, and water mercury concentration, the accumulation of mercury in fish is also dependent on environmental pH, redox potential, temperature, alkalinity, buffering capacity, suspended sediment load, and geomorphology in individual water bodies (Andren and Nriagu, 1979; Berlin, 1986; WHO, 1989).

Chemical concentrations for the data presented below are reported in wet weight. Arithmetic means, rather than geometric means, were used to represent the central tendency (average) of mercury concentrations for all species in this report. In general, arithmetic means for environmental chemical exposures are more health-protective than geometric means, and are commonly used in human health risk assessments. The mean mercury concentration, length, and sample size for each species collected and analyzed for Lake Sonoma and Lake Mendocino are presented in Table 1. Complete descriptive statistics for each fish species in this study can be found in Appendix IV; individual mercury concentrations and fish lengths from which species means were generated can be found in Appendix III. All fish lengths that were reported in fork length were converted to total length for the purpose of calculating mean lengths; conversion factors for estimating total length from measured fork lengths were developed for each species by OEHHA based on the degree of the angle in the fork of the tail fin. The lengths as originally reported, however, are included in Appendix III.

An adequate number of samples was available for largemouth bass and redear sunfish from both Lake Sonoma and Lake Mendocino. Black crappie were also sampled from Lake Sonoma. Only one composite of five fish met the minimum size criterion of 150 mm; however, a second composite of black crappie that averaged 145 mm in length was also considered in the evaluation because the five-millimeter difference was considered relatively insignificant given that minimum "edible" sizes for species without legal minimum criteria are only estimates. Other species that were collected at Lake Mendocino but did not meet the criterion of nine fish per species were channel catfish, striped bass, and rainbow trout.

Mean mercury concentrations in legal size largemouth bass were 0.82 ppm and 0.55 ppm at Lake Sonoma and Lake Mendocino, respectively. The mean length of bass samples was nearly equivalent at Lake Sonoma and at Lake Mendocino (370 mm and 379 mm, respectively). Edible

size redear sunfish had similar concentrations of mercury at the two lakes (0.25 ppm at Lake Sonoma and 0.26 ppm at Lake Mendocino), although redear sunfish from Lake Mendocino were considerably larger (285 mm versus 167 mm, respectively). The mean mercury concentration in black crappie at Lake Sonoma was 0.25 ppm.

Other common species in these lakes that were not sampled include smallmouth bass, channel catfish, landlocked steelhead, bluegill, and Sacramento perch at Lake Sonoma; and smallmouth bass and crappie from Lake Mendocino.

Fish consumption guidelines are appropriate whenever there are sufficient data to suggest that adverse health effects may occur from unrestricted consumption of individual fish species at certain sites. When sample size for a particular species from a water body is too small to assure a representative sample, that is, when there are less than nine individual or three composite samples for a given species at a water body, the data are not adequate for issuing specific advice. Channel catfish samples from Lake Mendocino exemplify the problem with using small sample sizes to represent a fish population. Mercury concentrations in the four individual catfish that were sampled ranged from 0.09 to 0.63 ppm, encompassing consumption guidelines from nearly 12 meals a month to one meal a month for women of childbearing age and children, and 30 meals a month to four meals a month for women beyond childbearing age and men. Additional samples would therefore be needed to more accurately estimate the true mean mercury concentration in this fish population.

Reasonably reliable guidelines can be provided for species that are closely related to those that were adequately sampled, have similar trophic levels, and that typically show similar mercury concentrations when sampled from the same water body. Data from other water bodies in northern California have shown this to be the case for black bass species, sunfish, and crappie (*e.g.*, Gassel *et al*., 2005; Gassel *et al*., 2006). Consequently, advice provided for largemouth bass can be extended to smallmouth bass; and guidelines for black crappie are applicable to white crappie. Consumption guidelines for redear sunfish are likely to be protective for consumption of other sunfish species such as Sacramento perch and bluegill.

Crappie were not sampled at Lake Mendocino, and therefore specific advice can not be provided for them. However, following the same guidelines provided for black crappie from Lake Sonoma for crappie collected from Lake Mendocino is likely to be health protective because the other fish species sampled at both lakes were either similar in mercury concentrations (*i.e*., redear sunfish) or higher at Lake Sonoma (*i.e*., largemouth bass).

Sample sizes for rainbow trout, striped bass, and channel catfish were insufficient to issue specific advice for these species in these lakes, and there were no other related species that could be used to compare mercury concentrations. Data from other water bodies in northern California indicate that, generally speaking, trout accumulate less mercury (Klasing *et al*., 2005), whereas catfish accumulate more (Gassel *et al*., 2006). The mean mercury concentration in seven striped bass from Lake Mendocino was higher than it was in largemouth bass, suggesting that striped bass should not be eaten more frequently or in place of black bass. The catfish samples had moderate levels of mercury. Consumers can take this information into account when choosing fish species to eat despite the lack of a scientifically defensible sample size for developing specific advice for these species in these two lakes.

FISH CONSUMPTION GUIDELINES FOR LAKE SONOMA AND LAKE MENDOCINO

Guidance tissue levels for chemicals of concern in fish have been developed that relate the number and size of recommended fish meals to methylmercury concentrations found in fish (Table 2). OEHHA has developed guidance tissue levels for mercury or methylmercury (Brodberg and Klasing, 2003) similar to risk-based consumption limits recommended by U.S. EPA (U.S. EPA, 2000b). These guidance values were designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for methylmercury. Meal sizes are based on a standard 8-ounce (227 grams) portion of uncooked fish (approximately 6 ounces after cooking) for adults who weigh approximately 70 kilograms (equivalent to 154 pounds), and the assumption that meal size corresponds to body weight. Consumers can adjust their meal size to stay within advisory guidelines by adding or subtracting one ounce of fish, respectively, for each 20-pound difference in body weight. OEHHA generally issues site-specific consumption advice beginning at a consumption frequency of twelve meals per month (three times a week). Fish that can be eaten at this frequency represent fish with lower levels of mercury. OEHHA encourages greater consumption of fish in this category, designated as "Best Choices" in order for consumers to continue eating fish while minimizing the risk. OEHHA typically also uses other consumption frequencies of eight meals a month, four meals a month, one meal a month, and no consumption. Tissue guidance levels for women beyond their childbearing years and men are approximately three times higher than for sensitive populations because of the three-fold higher RfD used for this population group. The sensitive population is defined as women of childbearing age (including women who are pregnant or breastfeeding) and children aged 17 years and younger.

All fish species with a minimum of nine fish per sample were compared to the guidance tissue levels to develop consumption guidelines. Common species in these two lakes that were not sampled but are closely related to species that were sampled, such as smallmouth bass, bluegill, and white crappie, were included in the safe eating guidelines for the related species with adequate sample sizes (largemouth bass, redear sunfish, and black crappie, respectively).

Safe Eating Guidelines for Lake Sonoma

It is recommended that **women of childbearing age and children aged 17 years and younger** limit consumption of black bass (largemouth bass or smallmouth bass) to no more one meal per month. Alternatively, this population can eat one meal per week of redear sunfish or other sunfish, or crappie.

For **women beyond their childbearing years and men**, OEHHA recommends that consumption of black bass (largemouth bass or smallmouth bass) be limited to no more one meal per week. The best choices for this population include redear sunfish or another sunfish species, or crappie, which can be eaten up to two meals per week.

Safe Eating Guidelines for Lake Mendocino

It is recommended that **women of childbearing age and children aged 17 years and younger** limit consumption of black bass (largemouth bass or smallmouth bass) to no more one meal per month. Alternatively, this population can eat one meal per week of redear sunfish or other sunfish. Based on guidelines for crappie from Lake Sonoma, a meal of crappie from Lake Mendocino could be substituted for a meal of sunfish in a given week. Incomplete information indicates that consumption of striped bass should be avoided, and catfish should be eaten in limited amounts, such as no more than once a week.

For **women beyond their childbearing years and men**, OEHHA recommends that consumption of black bass (largemouth bass or smallmouth bass) be limited to no more one meal per week. The best choices for this population include redear sunfish or another sunfish species. Based on guidelines for crappie from Lake Sonoma, a meal of crappie from Lake Mendocino could be substituted for a meal of sunfish.

Consumers should be informed of the potential hazards from eating fish with high mercury concentrations, particularly those hazards relating to the developing fetus and children, as well as the fish species that contain less mercury and therefore provide better options when choosing fish to eat. All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to limit their consumption of high-mercury fish to reduce methylmercury ingestion to a level as close to the RfD as possible. In addition, consumption of fish species that have less restrictive advice (for example, once a week compared to once a month) is encouraged because it allows consumers to eat more fish and thereby experience the benefits of fish consumption while reducing the risk of adverse health effects. Recreational fishers may opt to practice catch-and-release for species that have high levels of mercury.

It is very important to note that if an individual consumes multiple species or catches fish from more than one site, the recommended guidelines for different species and locations should not be combined (*i.e*., added). For example, if a pregnant woman were to eat a meal of black bass from Lake Sonoma or Lake Mendocino, she should not eat any other fish that month. Alternatively, she could eat one meal of sunfish each week, or two meals a week of store-bought fish low in mercury as recommended by the American Heart Association, and the joint advisory from U.S. EPA and FDA (as described below), in place of the meal of sport-caught sunfish.

OEHHA also recommends that **women of childbearing age and children aged 17 and younger** follow the Joint Federal Advisory for Mercury in Fish for commercial fish. This advisory recommends that these individuals do not eat shark, swordfish, king mackerel, or tilefish because of their high mercury levels. The federal advisory also states that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased at stores or restaurants such as shrimp, canned light tuna, wild salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. Also, if 12 ounces of cooked fish from a store or restaurant are eaten in a given week, then OEHHA recommends that sport fish caught at Lake Sonoma, Lake Mendocino, or other California water bodies should not be consumed in the same week.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), see Appendix II. It should be noted that, unlike the case for many fat-soluble organic contaminants (*e.g.*, DDTs and PCBs), various cooking and cleaning techniques will not reduce the methylmercury content of fish. Meal sizes should be adjusted to body weight as described in the advisory table. The complete recommendations (safe eating guidelines) for consumption of fish from Lake Sonoma and Lake Mendocino are presented in the tables below.

SAFE EATING GUIDELINES
FISH CONSUMPTION FROM LAKE SONOMA

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. The American Heart Association recommends healthy adults eat at least two meals of fish a week. OEHHA recommends that you choose fish to eat that are lower in mercury. Because some types of fish from Lake Sonoma contain high levels of mercury, OEHHA provides the recommendations below that you can follow to reduce the risks from exposure to methylmercury in fish.

Women of childbearing age, pregnant or breastfeeding women, and children 17 years and younger

EAT IN MODERATION **No more than 1 meal a week**
Sunfish or crappie
AVOID **No more than 1 meal a month**
Largemouth or smallmouth bass

Women beyond childbearing age and men

BEST CHOICES **Up to 2 meals a week**
Sunfish or crappie
EAT IN MODERATION **No more than 1 meal a week**
Largemouth or smallmouth bass

- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish build up mercury in their bodies as they grow.
- **MEAL SIZE DEPENDS ON BODY WEIGHT.** Meals are based on a 160-pound adult eating 8 ounces of fish (6 ounces after cooking) — about the size of two decks of cards. If you weigh less than 160 pounds, eat smaller portions of fish. Serve smaller meals to children.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. Do not eat more than one of the listed fish species during the same time period unless you are eating from the Best Choices (green) category. If you eat fish from one place, following the advisory, avoid eating fish from other sources during the same time period.
- **CONSIDER THE FISH YOU BUY FROM STORES AND RESTAURANTS.** Women of childbearing age and children can safely eat up to 2 meals a week of most fish purchased in a store or restaurant, **OR** use this guide for eating fish caught from this water body. In a week when you eat 2 meals of fish purchased from stores or restaurants, avoid eating fish caught from a local water body. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury. Women of childbearing age and children should not eat shark or swordfish, which contain the most mercury.
- **FISH FROM OTHER WATER BODIES MAY ALSO CONTAIN MERCURY**. Not all water bodies in California have been tested. With the exception of ocean or river-run salmon or steelhead, which may be consumed more frequently, fish caught from places without an advisory should be eaten in limited amounts.

SAFE EATING GUIDELINES
FISH CONSUMPTION FROM LAKE MENDOCINO

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. The American Heart Association recommends healthy adults eat at least two meals of fish a week. OEHHA recommends that you choose fish to eat that are lower in mercury. Because some types of fish from Lake Mendocino contain high levels of mercury, OEHHA provides the recommendations below that you can follow to reduce the risks from exposure to methylmercury in fish.

Women of childbearing age, pregnant or breastfeeding women, and children 17 years and younger

EAT IN MODERATION **No more than 1 meal a week**
Sunfish or crappie
AVOID **No more than 1 meal a month**
Largemouth or smallmouth bass

Women beyond childbearing age and men

BEST CHOICES **Up to 2 meals a week**
Sunfish or crappie
EAT IN MODERATION **No more than 1 meal a week**
Largemouth or smallmouth bass

- Incomplete information from Lake Mendocino indicates that you should avoid eating striped bass, and channel catfish should be eaten in limited amounts (no more than 1 meal a week).
- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish build up mercury in their bodies as they grow.
- **MEAL SIZE DEPENDS ON BODY WEIGHT.** Meals are based on a 160-pound adult eating 8 ounces of fish (6 ounces after cooking) — about the size of two decks of cards. If you weigh less than 160 pounds, eat smaller portions of fish. Serve smaller meals to children.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. Do not eat more than one of the listed fish species during the same time period unless you are eating from the Best Choices (green) category. If you eat fish from one place, following the advisory, avoid eating fish from other sources during the same time period.
- **CONSIDER THE FISH YOU BUY FROM STORES AND RESTAURANTS.** Women of childbearing age and children can safely eat up to 2 meals a week of most fish purchased in a store or restaurant, **OR** use this guide for eating fish caught from this water body. In a week when you eat 2 meals of fish purchased from stores or restaurants, avoid eating fish caught from a local water body. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury. Women of childbearing age and children should not eat shark or swordfish, which contain the most mercury.
- **FISH FROM OTHER WATER BODIES MAY ALSO CONTAIN MERCURY**. Not all water bodies in California have been tested. With the exception of ocean or river-run salmon or steelhead, which may be consumed more frequently, fish caught from places without an advisory should be eaten in limited amounts.

RECOMMENDATIONS FOR FURTHER SAMPLING

It is recommended that further fish sampling be done to more clearly elucidate mercury contamination problems in Lake Sonoma and Lake Mendocino. In particular, emphasis should be placed on collecting data for popular fish species that were not previously sampled or had low sample size, including catfish, striped bass, rainbow trout/steelhead, and bluegill and other sunfish species. Sampling at least nine fish of each of these species would provide the scientific basis for fish consumption guidelines. Additional data on fish species that are typically low in mercury, such as trout, can provide anglers and their families with more options for choosing lower-mercury fish to eat from these lakes. Furthermore, samples of fatty fish species, particularly catfish, from Lake Sonoma and Lake Mendocino need to be analyzed for pesticides and PCBs to determine whether consumption of these fish could pose a potential threat to human health from exposure to these contaminants.

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Table 1. Summary Statistics for Legal and/or Edible Size Fish from Lake Sonoma and Lake Mendocino

Species	*Mean Mercury (ppm)*	*Mean Length (mm TL)*	*Minimum Size[1] (mm TL)*	*# Samples*	*Total # Fish*
Lake Sonoma					
Largemouth bass	**0.82**	370	305	14	64
Redear sunfish	**0.25**	167	130	6	27
Black crappie	0.24	167	150	1	5
Black crappie	0.26	145	150	1	5
Lake Mendocino					
Largemouth bass	**0.55**	379	305	7	36
Redear sunfish	**0.26**	285	130	2	12
Striped bass	0.74	622	415	2	7
Channel catfish	0.31	623	200	4	4
Rainbow trout	0.12	380	200	2	2

TL = total length
Values in **bold** indicate species with adequate samples sizes

[1] Minimum size criteria reflect the minimum legal size, if one exists, or otherwise, an estimate of the minimum size at which consumers are likely to eat a fish from the species, also taking into account the size at maturity for the species.

Table 2: Guidance Tissue Levels (ppm Total Mercury or Methylmercury*, wet weight) for Two Population Groups

Population group:	***Women of child-bearing age and children aged 17 years and younger***	***Women beyond childbearing age and men***
Reference Dose (RfD):	*1×10^{-4} mg/kg/day*	*3×10^{-4} mg/kg/day*
Meals per Month	***Tissue concentration (ppm)***	
30	$\leq$ 0.03	$\leq$ 0.09
12	> 0.03 – 0.08	> 0.09 – 0.23
8	> 0.08 – 0.12	> 0.23 – 0.35
7	> 0.12 – 0.13	> 0.35 – 0.40
6	> 0.13 – 0.16	> 0.40 – 0.47
5	> 0.16 – 0.19	> 0.47 – 0.56
4	> 0.19 – 0.23	> 0.56 – 0.70
3	> 0.23 – 0.31	> 0.70 – 0.94
2	> 0.31 – 0.47	> 0.94 – 1.40
1	> 0.47 – 0.94	> 1.40 – 2.80
0	> 0.94	> 2.80

*The values in this table are based on the assumption that 100% of total mercury measured in fish is methylmercury. This may not be true for shellfish, so methylmercury needs to be measured directly in these species for use in this table.

The following general equation can be used to calculate the fish tissue concentration (in mg/kg) at which the consumption exposure from a chemical with a non-carcinogenic effect is equal to the reference level for that chemical at any consumption level:

$$\text{Tissue concentration} = \frac{(\text{RfD mg/kg - day})(\text{kg Body Weight})(\text{RSC})}{\text{CR kg/day}}$$

where,

RfD = Chemical specific reference dose or other reference level
BW = Body weight of consumer
RSC = Relative source contribution of fish to total exposure
CR = Consumption rate as the daily amount of fish consumed

For example: $\frac{(1 \times 10^{-4}\ \text{mg/kg-day})(70\ \text{kg body weight})\ (1)}{.030\ \text{kg/day}} = 0.23\ \text{mg/kg tissue}$

This equation was applied above to determine tissue concentrations of methylmercury (assuming 100% of measured total mercury is methylmercury in fish) in sport fish that would be below or equivalent to the chemical's reference level when eating different amounts of fish.

Meal Sizes used in this table: Although people eat different meal sizes, their typical portion size is related to their individual body weight in a fairly consistent manner. The standard portion size eaten by an average adult (body weight 70 kg or 154 pounds) is eight ounces (0.227 kg) (U.S. EPA, 2000b). A standard portion of one fish meal a month is equivalent to .0075 kg/day, one meal per week is equivalent to .030 kg/day, two meals per week is equivalent to .060 g/day, and three meals per week is equivalent to .090 g/day. In some cases, fish tissue concentrations corresponding to intermediate meal frequencies were incorporated into the standard meal categories used for providing "safe eating guidelines" such that the hazard quotient (the ratio of exposure to the reference dose) did not exceed unity (1), including rounding.

Figure 1. Map of Lake Sonoma

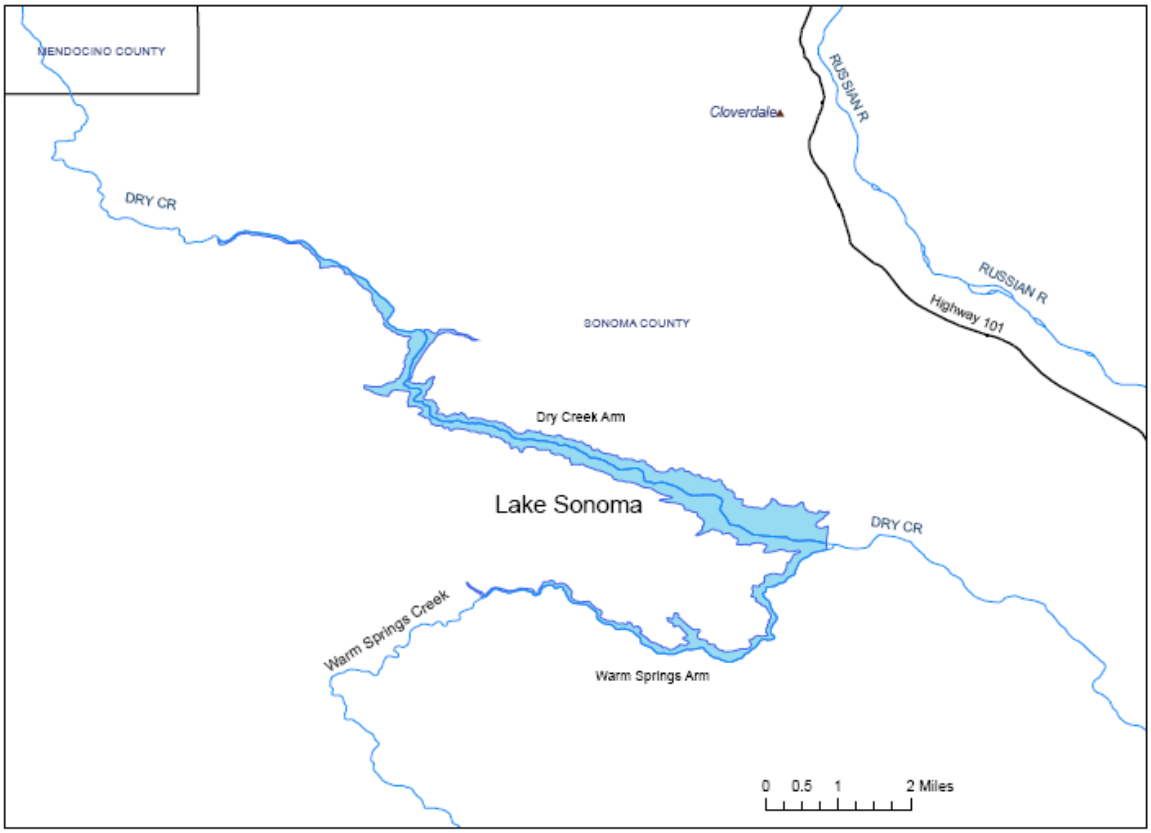
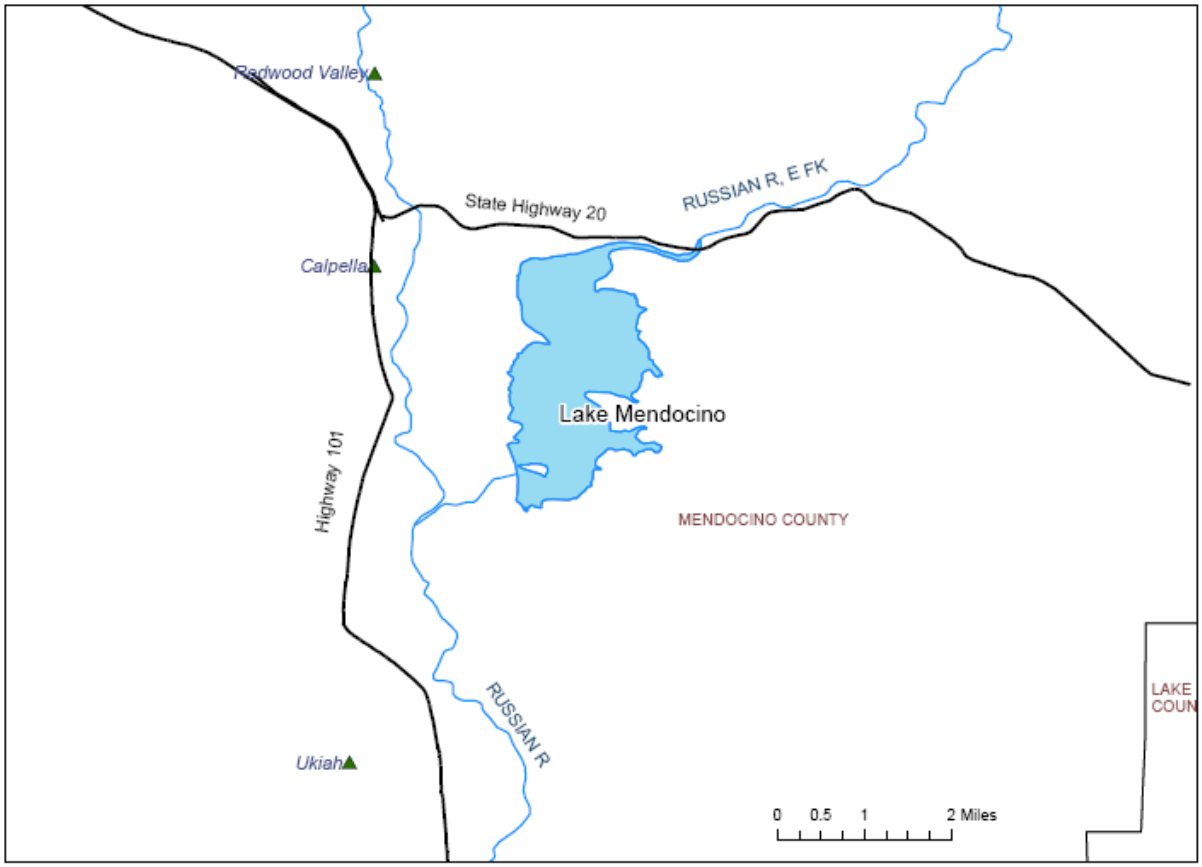


Figure 2. Map of Lake Mendocino



Appendix I: Methylmercury in Sport Fish: Information for Fish Consumers

Methylmercury is a form of mercury that is found in most freshwater and saltwater fish. In some lakes, rivers, and coastal waters in California, methylmercury has been found in some types of fish at concentrations that may be harmful to human health. The Office of Environmental Health Hazard Assessment (OEHHA) has issued health advisories to fishers and their families giving recommendations on how much of the affected fish in these areas can be safely eaten. In these advisories, women of childbearing age and children are encouraged to be especially careful about following the advice because of the greater sensitivity of fetuses and children to methylmercury.

Fish are nutritious and should be a part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation. OEHHA provides advice to the public so that people can continue to eat fish without putting their health at risk.

WHERE DOES METHYLMERCURY IN FISH COME FROM?

Methylmercury in fish comes from mercury in the aquatic environment. Mercury, a metal, is widely found in nature in rock and soil, and is washed into surface waters during storms. Mercury evaporates from rock, soil, and water into the air, and then falls back to the earth in rain, often far from where it started. Human activities redistribute mercury and can increase its concentration in the aquatic environment. The coastal mountains in northern California are naturally rich in mercury in the form of cinnabar ore, which was processed to produce quicksilver, a liquid form of inorganic mercury. This mercury was taken to the Sierra Nevada, Klamath mountains, and other regions, where it was used in gold mining. Historic mining operations and the remaining tailings from abandoned mercury and gold mines have contributed to the release of large amounts of mercury into California's surface waters. Mercury can also be released into the environment from industrial sources, including the burning of fossil fuels and solid wastes, and disposal of mercury-containing products.

Once mercury gets into water, much of it settles to the bottom where bacteria in the mud or sand convert it to the organic form of methylmercury. Fish absorb methylmercury when they eat smaller aquatic organisms. Larger and older fish absorb more methylmercury as they eat other fish. In this way, the amount of methylmercury builds up as it passes through the food chain. Fish eliminate methylmercury slowly, and so it builds up in fish in much greater concentrations than in the surrounding water. Methylmercury generally reaches the highest levels in predatory fish at the top of the aquatic food chain.

HOW MIGHT I BE EXPOSED TO METHYLMERCURY?

Eating fish is the main way that people are exposed to methylmercury. Each person's exposure depends on the amount of methylmercury in the fish that they eat and how much and how often they eat fish.

Women can pass methylmercury to their babies during pregnancy, and this includes methylmercury that has built up in the mother's body even before pregnancy. For this reason, women of childbearing age are encouraged to be especially careful to follow consumption advice, even if they are not pregnant. In addition, nursing mothers can pass methylmercury to their child through breast milk.

You may be exposed to inorganic forms of mercury through dental amalgams (fillings) or accidental spills, such as from a broken thermometer. For most people, these sources of exposure to mercury are minor and of less concern than exposure to methylmercury in fish.

AT WHAT LOCATIONS IN CALIFORNIA HAVE ELEVATED LEVELS OF MERCURY BEEN FOUND IN FISH?

Methylmercury is found in most fish, but some fish and some locations have higher amounts than others. Methylmercury is one of the chemicals in fish that most often creates a health concern. Consumption advisories due to high levels of methylmercury in fish have been issued in about 40 states. In California, methylmercury advisories have been issued for San Francisco Bay and the Delta; Tomales Bay in Marin County; and at the following inland lakes: Lake Nacimiento in San Luis Obispo County; Lake Pillsbury and Clear Lake in Lake County; Lake Berryessa in Napa County; Guadalupe Reservoir and associated reservoirs in Santa Clara County; Lake Herman in Solano County; San Pablo Reservoir in Contra Costa County; Black Butte Reservoir in Glenn and Tehama Counties; Lake Natoma and the lower American River in Sacramento County; Trinity Lake in Trinity County; and certain lakes and river stretches in the Sierra Nevada foothills in Nevada, Placer, and Yuba counties. Other locations may be added in the future as more fish and additional water bodies are tested.

HOW DOES METHYLMERCURY AFFECT HEALTH?

Much of what we know about methylmercury toxicity in humans stems from several mass poisoning events that occurred in Japan during the 1950s and 1960s, and Iraq during the 1970s. In Japan, a chemical factory discharged vast quantities of mercury into several bays near fishing villages. Many people who consumed large amounts of fish from these bays became seriously ill or died over a period of several years. In Iraq, thousands of people were poisoned by eating contaminated bread that was mistakenly made from seed grain treated with methylmercury.

From studying these cases, researchers have determined that the main target of methylmercury toxicity is the central nervous system. At the highest exposure levels experienced in these poisonings, methylmercury toxicity symptoms included such nervous system effects as loss of coordination, blurred vision or blindness, and hearing and speech impairment. Scientists also discovered that the developing nervous systems of fetuses are particularly sensitive to the toxic effects of methylmercury. In the Japanese outbreak, for example, some fetuses developed methylmercury toxicity during pregnancy even when their mothers did not. Symptoms reported in the Japan and Iraq epidemics resulted from methylmercury levels that were much higher than what fish consumers in the U.S. would experience.

Individual cases of adverse health effects from heavy consumption of commercial fish containing moderate to high levels of methylmercury have been reported only rarely. Nervous system symptoms reported in these instances included headaches, fatigue, blurred vision, tremor, and/or some loss of concentration, coordination, or memory. However, because there was no clear link between the severity of symptoms and the amount of mercury to which the person was exposed, it is not possible to say with certainly that these effects were a consequence of methylmercury exposure and not the result of other health problems. The most subtle symptoms in adults known to be clearly associated with methylmercury toxicity are numbness or tingling in the hands and feet or around the mouth; however, these symptoms are also associated with other medical conditions not related to methylmercury exposure.

In recent studies of high fish-eating populations in different parts of the world, researchers have been able to detect more subtle effects of methylmercury toxicity in children whose mothers

frequently ate seafood containing low to moderate mercury concentrations during their pregnancy. Several studies found slight decreases in learning ability, language skills, attention and/or memory in some of these children. These effects were not obvious without using very specialized and sensitive tests. Children may have increased susceptibility to the effects of methylmercury through adolescence, as the nervous system continues to develop during this time.

Methylmercury builds up in the body if exposure continues to occur over time. Exposure to relatively high doses of methylmercury for a long period of time may also cause problems in other organs such as the kidneys and heart.

CAN MERCURY POISONING OCCUR FROM EATING SPORT FISH IN CALIFORNIA?

No case of mercury poisoning has been reported from eating California sport fish. The levels of mercury in California fish are much lower than those that occurred during the Japanese outbreak. Therefore, overt poisoning resulting from sport fish consumption in California would not be expected. At the levels of mercury found in California fish, symptoms associated with methylmercury are unlikely unless someone eats much more than what is recommended or is particularly sensitive. The fish consumption guidelines are designed to protect against subtle effects that would be difficult to detect but could still occur following unrestricted consumption of California sport fish. This is especially true in the case of fetuses and children.

IS THERE A WAY TO REDUCE METHYLMERCURY IN FISH TO MAKE THEM SAFER TO EAT?

There is no specific method of cleaning or cooking fish that will significantly reduce the amount of methylmercury in the fish. However, fish should be cleaned and gutted before cooking because some mercury may be present in the liver and other organs of the fish. These organs should not be eaten.

In the case of methylmercury, fish size is important because large fish that prey upon smaller fish can accumulate more of the chemical in their bodies. It is better to eat the smaller fish within the same species, provided that they are legal size.

IS THERE A MEDICAL TEST TO DETERMINE EXPOSURE TO METHYLMERCURY?

Mercury in blood and hair can be measured to assess methylmercury exposure. However, this is not routinely done. Special techniques in sample collection, preparation, and analysis are required for these tests to be accurate. Although tests using hair are less invasive, they are also less accurate. It is important to consult with a physician before undertaking medical testing because these tests alone cannot determine the cause of personal symptoms.

HOW CAN I REDUCE THE AMOUNT OF METHYLMERCURY IN MY BODY?

Methylmercury is eliminated from the body over time provided that the amount of mercury taken in is reduced. Therefore, following the OEHHA consumption advice and eating less of the fish that have higher levels of mercury can reduce your exposure and help to decrease the levels of methylmercury already in your body if you have not followed these recommendations in the past.

WHAT IF I EAT FISH FROM OTHER SOURCES SUCH AS RESTAURANTS, STORES, OR OTHER WATER BODIES THAT MAY NOT HAVE AN ADVISORY?

Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. In 2004, FDA and the U.S. Environmental Protection Agency (U.S. EPA) issued a Joint Federal Advisory for Mercury in Fish advising women who are pregnant or could become

pregnant, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish. The federal advisory also recommends that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased in stores or restaurants, such as shrimp, canned light tuna, salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. In addition, the federal advisory recommends that women who are pregnant or may become pregnant, nursing mothers, and young children consume no more than one meal per week of locally caught fish, when no other advice is available, and eat no other fish that week. The federal advisory can be found at http://www.cfsan.fda.gov/~dms/admehg.html or http://www.epa.gov/ost/fishadvice/advice.html.

In addition, OEHHA offers the following general advice that can be followed to reduce exposure to methylmercury in fish. Chemical levels can vary from place to place. Therefore, your overall exposure to chemicals is likely to be lower if you fish at a variety of places, rather than at one location that might have high contamination levels. Furthermore, some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants. Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may become more concentrated in larger, older fish. It is advisable to eat smaller fish (of legal size) more often than larger fish. Cleaning and cooking fish in a manner that removes fat and organs is an effective way to reduce other contaminants that may be present in fish.

WHERE CAN I GET MORE INFORMATION?

The health advisories for sport fish are printed in the California Sport Fishing Regulations booklet, which is available wherever fishing licenses are sold. OEHHA also offers a booklet containing the advisories, and additional materials such as this fact sheet on related topics. Additional information and documents related to fish advisories are available on the OEHHA Web Site at http://www.oehha.ca.gov/fish.html. County departments of environmental health may have more information on specific fishing areas.

Appendix II. General Advice for Sport Fish Consumption

You can reduce your exposure to chemical contaminants in sport fish by following the recommendations below. Follow as many of them as you can to increase your health protection. This general advice is not meant to take the place of advisories for specific areas, but should be followed in addition to them. Sport fish in most water bodies in the state have not been evaluated for their safety for human consumption. This is why we strongly recommend following the general advice given below.

Fishing Practices

Chemical levels can vary from place to place. Your overall exposure to chemicals is likely to be lower if you eat fish from a variety of places rather than from one usual spot that might have high contamination levels.

Be aware that OEHHA may issue new advisories or revise existing ones. Consult the Department of Fish and Game regulations booklet or check with OEHHA on a regular basis to see if there are any changes that could affect you.

Consumption Guidelines

Fish Species: Some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants.

Fish Size: Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may accumulate as the fish grows. It is advisable to eat smaller fish (of legal size).

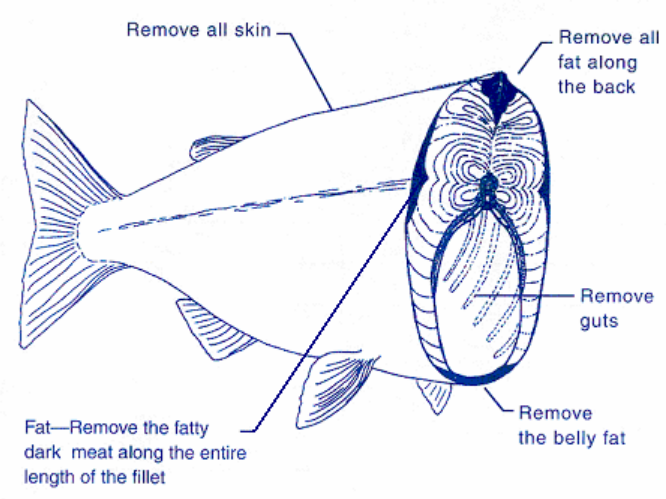
Fish Preparation and Consumption

• Eat only the fillet portions. Do not eat the guts and liver because chemicals usually concentrate in those parts. Also, avoid frequent consumption of any reproductive parts such as eggs or roe.

• Many chemicals are stored in the fat. To reduce the levels of these chemicals, skin the fish when possible and trim any visible fat.

• Use a cooking method such as baking, broiling, grilling, or steaming that allows the juices to drain away from the fish. The juices will contain chemicals in the fat and should be thrown away. Preparing and cooking fish in this way can remove 30 to 50 percent of the chemicals stored in fat. If you make stews or chowders, use fillet parts.

• Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites.



Advice For Pregnant Women, Women of Childbearing Age, and Children

Children and fetuses are more sensitive to the toxic effects of methylmercury, the form of mercury of health concern in fish. For this reason, OEHHA's advisories that are based on mercury provide special advice for women of childbearing age and children. Women should follow this advice throughout their childbearing years.

The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. In 2004, FDA and the U.S. Environmental Protection Agency (U.S. EPA) issued a Joint Federal Advisory for Mercury in Fish advising women who are pregnant or could become pregnant, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish. The federal advisory also recommends that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased in stores or restaurants, such as shrimp, canned light tuna, salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. In addition, the federal advisory recommends that women who are pregnant or may become pregnant, nursing mothers, and young children consume no more than one meal per week of locally caught fish, when no other advice is available, and eat no other fish that week. The federal advisory can be found at http://www.cfsan.fda.gov/~dms/admehg.html or http://www.epa.gov/ost/fishadvice/advice.html.

Appendix III. Case Summaries for Fish Samples from Lake Sonoma and Lake Mendocino[1]

Common Name	Station Name	Year	#	Total Length (mm)	Fork Length (mm)	Mercury (wet wt. ppm)	Legal and/or Edible Size[2]
Channel Catfish	Lake Mendocino	2001	1	618.7	538.0	.626	1
Channel Catfish	Lake Mendocino	2001	1	649.8	565.0	.086	1
Channel Catfish	Lake Mendocino	2001	1	707.5	615.2	.126	1
Channel Catfish	Lake Mendocino	2001	1	891.3	775.0	.398	1
Largemouth Bass	Lake Mendocino	1993	6	302.4	288.0	.250	0
Largemouth Bass	Lake Mendocino	1990	6	321.3	306.0	.490	1
Largemouth Bass	Lake Mendocino	1991	6	366.5	349.0	.320	1
Largemouth Bass	Lake Mendocino	2001	4	400.1	381.0	.473	1
Largemouth Bass	Lake Mendocino	2001	4	456.8	435.0	.701	1
Largemouth Bass	Lake Mendocino	2001	4	518.7	494.0	.806	1
Rainbow Trout	Lake Mendocino	2001	1	374.1	365.0	.115	1
Rainbow Trout	Lake Mendocino	2001	1	403.9	394.0	.120	1
Redear Sunfish	Lake Mendocino	1992	6	288.0	281.0	.250	1
Redear Sunfish	Lake Mendocino	1993	6	295.2	288.0	.270	1
Striped Bass	Lake Mendocino	2001	1	594.0	540.0	.753	1
Striped Bass	Lake Mendocino	1989	6	699.6	636.0	.740	1
Largemouth Bass	Lake Mendocino/South End	2000	6	287.7	274.0	.346	0
Largemouth Bass	Lake Mendocino/South End	2000	6	360.2	343.0	.517	1
Largemouth Bass	Lake Mendocino/South End	2000	6	422.1	402.0	.651	1
Largemouth Bass	Lake Sonoma	2000	6	188.0	179.0	.559	0
Largemouth Bass	Lake Sonoma	1996	6	200.6	191.0	.310	0
Largemouth Bass	Lake Sonoma	1992	12	218.4	208.0	.500	0
Largemouth Bass	Lake Sonoma	2000	6	275.1	262.0	.840	0
Largemouth Bass	Lake Sonoma	1995	6	280.4	267.0	.570	0
Largemouth Bass	Lake Sonoma	1989	6	298.2	284.0	.770	0
Largemouth Bass	Lake Sonoma	1993	6	302.4	288.0	.880	0
Largemouth Bass	Lake Sonoma	1991	6	306.6	292.0	.870	1
Largemouth Bass	Lake Sonoma	1997	3	356.0	339.0	.472	1
Largemouth Bass	Lake Sonoma	1990	6	366.5	349.0	.360	1
Largemouth Bass	Lake Sonoma	2000	6	375.9	358.0	.461	1
Largemouth Bass	Lake Sonoma	1995	3	440.0	419.0	1.800	1
Redear Sunfish	Lake Sonoma	1993	7	178.4	174.0	.310	1
Redear Sunfish	Lake Sonoma	1993	6	179.4	175.0	.300	1
Largemouth Bass	Lake Sonoma/Dry Creek Arm	2000	7	207.9	198.0	.513	0

[1] All data from TSMP

[2] A "1" signifies data meeting the legal and/or edible size criteria that were therefore used; "0" indicates data not used because they did not meet the size criteria

Common Name	Station Name	Year	#	Total Length (mm)	Fork Length (mm)	Mercury (wet wt. ppm)	Legal and/or Edible Size[2]
Largemouth Bass	Lake Sonoma/Dry Creek Arm	2000	6	259.4	247.0	.595	0
Largemouth Bass	Lake Sonoma/Dry Creek Arm	2000	6	380.1	362.0	.501	1
Largemouth Bass	Lake Sonoma/Dry Creek Arm	2001	5	426.3	406.0	.883	1
Redear Sunfish	Lake Sonoma/Dry Creek Arm	2001	3	177.3	173.0	.140	1
Black Crappie	Lake Sonoma/Upper Warm Springs Arm	2001	4	144.2	140.0	.256	0
Black Crappie	Lake Sonoma/Upper Warm Springs Arm	2001	5	172.0	167.0	.240	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	1997	6	323.4	308.0	.370	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	2001	5	366.5	349.0	.867	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	1996	6	371.7	354.0	.970	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	2001	5	451.5	430.0	1.240	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	2001	5	484.1	461.0	1.220	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	2001	1	530.3	505.0	1.560	1
Largemouth Bass	Lake Sonoma/Upper Warm Springs Arm	2001	1	567.0	540.0	1.590	1
Redear Sunfish	Lake Sonoma/Upper Warm Springs Arm	2001	7	131.2	128.0	.156	1
Redear Sunfish	Lake Sonoma/Upper Warm Springs Arm	2001	3	190.7	186.0	.228	1
Redear Sunfish	Lake Sonoma/Upper Warm Springs Arm	2001	1	281.9	275.0	.595	1

Length conversions:

Striped Bass	Total Length = 1.100 * Fork Length
Largemouth Bass	Total Length = 1.050 * Fork Length
Rainbow Trout	Total Length = 1.025 * Fork Length
Redear Sunfish	Total Length = 1.025 * Fork Length
Black Crappie	Total Length = 1.030 * Fork Length

Appendix IV. Descriptive Statistics for Legal and/or Edible Size Fish from Lakes Sonoma and Mendocino

Descriptive Statistics[1] for Mercury Concentration (ppm, wet weight) and Length (mm)[2] from Lake Sonoma and Lake Mendocino

	Mercury ppm						*Total Length mm*[2]						*Sample Size*							
Species	*Mean*	*Median*	*SD*	Min	*Max*	*95% CI*	*Mean*	*Median*	*SD*	Min	*Max*	*95% CI*	*1 per sample*	*3 per sample*	*4 per sample*	*5 per sample*	*6 per sample*	*7 per sample*	Total # samples	*Total N*
Lake Sonoma																				
Black Crappie	.24	.24	NA[3]	.24	.24	NA[3]	172	172	NA[3]	172	172	NA[3]	0	0	0	1	0	0	1	5
Largemouth Bass	.82	.87	.40	.36	1.80	.72-.92	389	374	58	307	567	374-403	2	2	0	4	6	0	14	64
Redear Sunfish	.25	.30	.10	.14	.60	.21-.29	171	178	31	131	282	159-184	1	2	0	0	1	2	6	27
Lake Mendocino																				
Channel Catfish	.31	.26	.25	.09	.63	.00-.71	717	679	122	619	891	523-911	4	0	0	0	0	0	4	4
Largemouth Bass	.55	.52	.15	.32	.81	.50-.60	398	383	60	321	519	378-418	0	0	3	0	4	0	7	36
Rainbow Trout	.12	.12	.00	.12	.12	.09-.15	389	389	21	374	404	200-578	2	0	0	0	0	0	2	2
Redear Sunfish	.26	.26	.01	.25	.27	.25-.27	292	292	4	288	295	289-294	0	0	0	0	2	0	2	12
Striped Bass	.74	.74	.00	.74	.75	.74-.75	685	700	40	594	700	648-721	1	0	0	0	1	0	2	7

[1] Data weighted by number of individuals per sample.

[2] Type of length is total length—longest length from tip of tail fin to tip of nose/mouth. TSMP fork length was converted to total length per OEHHA PETS conversion factors, *i.e.*, fork length times 1.03 for black crappie; times 1.05 for largemouth bass; times 1.025 for rainbow trout and redear sunfish, times 1.1 for striped bass, and times 1.15 for channel catfish. Length values for composite samples are reported as mean length.

[3] NA: Confidence Interval and Standard Deviation are not applicable since Mercury or Total length mm is constant.